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Mineralogical study of the Gonçalo Li-pegmatite deposit, Portugal

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Introduction

Beside the Scandinavian countries and Serbia, Portugal is among the European countries with the most significant lithium resources. The Li-rich occurrences in Portugal are mainly associated with aplite-pegmatite dykes and sills intruded in granitic and metasedimentary rocks of the Central Iberian and Galicia – Trás-os-Montes geotectonic zones (Carvalho & Farinha, 2004). The Gonçalo Li-pegmatites in the Guarda district (currently only used as decorative stone) have significant economic importance. Among other deposits, Gonçalo is a reference site in the focus of the EU FAME project (www.fame-project.eu) that aims to unlock the development potential of the most promising European Sn-W-Li ore types. Results of optical microscopy, QEMSCAN©, Raman and electron-probe microanalysis of the Gonçalo Li-pegmatite deposit have been employed to determine the mineralogical variability of the pegmatites with the aim to determine the deportment of lithium and potential rare-metal by-products and to guide enhanced mineral processing technologies.

Geological setting

The Gonçalo area is located in Central Iberian zone in the Beiras region of central Portugal (Figs. 1A, B). It is represented by a large field of aplite-pegmatite dykes and sills mainly intruded in the Guarda granite. The Gonçalo Li-pegmatite deposit (Fig. 2) is located 20 km SW of the Guarda town. The aplite-pegmatite field of Gonçalo, also called Gonçalo – Seixo Amarelo, is located 15 km southwest of the district capital Guarda. This important field is part of a very large region (~100 km^2, Fig. 1A) where several occurrences of rare metal-rich aplite-pegmatite dikes and sills ("veins") are intruding granitic rocks and also the schist-greywacke complex of the Central Iberian Zone of the Hesperian Massif (Carvalho & Farinha, 2004).

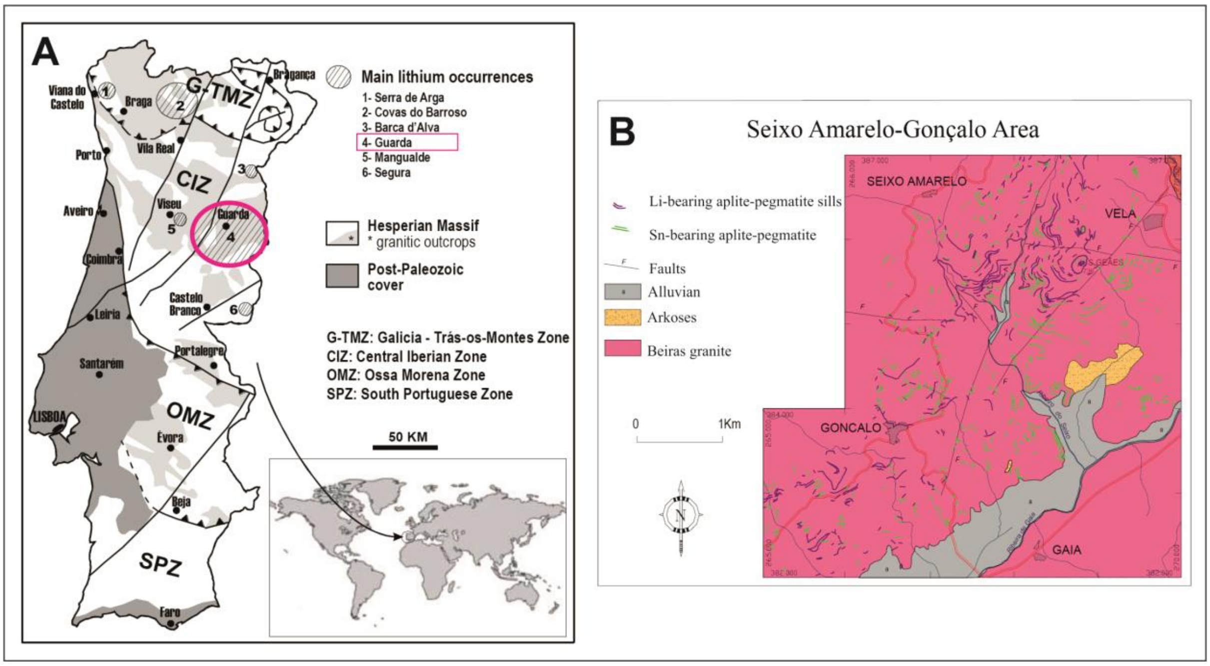

Figure 1*. A – Main Portuguese Li-rich mineral occurrences (after Carvalho & Farinha, 2004); B – Geologic map of the Gonçalo district (from Ramos, 2007).*

Figure 2. *Panoramic view of the Gonçalo pegmatite (photo: R. Armstrong).*

The outcrops of the pegmatite field are determined by sub-horizontal dipping and by late NNE-SSW to NE-SW and NW-SE subvertical faults that divide the field in several sectors (Fig. 1B). In a more detailed view we can verify that towards the south-east of the NE-SW Vela-Gonçalo regional fault, only Sn-bearing veins occur. However, to the north-west of this fault, in lower topographic levels occur Sn-bearing veins and in the uppermost topographic levels Li-bearing veins. The Li-rich veins present an average grade of 0.8 % Li_2O. The evaluated resources are 1.4 Mt. It is a minimum value because only the Li-rich sills and a maximum quarry front of 10 m high were considered. Therefore, it is an evaluation that considers only the part of the ore deposit exposed at surface.

Mineralogical characteristics

In the studied material from the Gonçalo quarries, the LCT pegmatites consist predominantly of 'lepidolite', albite, muscovite, quartz and K-feldspar as major minerals, and montebrasite, topaz, cassiterite, columbite-Mn, tantalite-Mn, beryl, and zircon as minor minerals. Petalite also occurs, but is scarce due to its alteration to kaolinite, cookeite and illite/smectite (Fig. 3A) in late episodes of pegmatite evolution. The aplitic component is characterized by a sodalithic composition with 'lepidolite', albite, amblygonite - montebrasite, and quartz as major minerals. Some muscovite, topaz, cassiterite, columbite-Mn and tantalite-Mn are also present. In both the pegmatites and aplites secondary phosphates are found, resulting from late alteration processes.

Figure 3. *A - Altered pegmatite (greenish: illite/smectite+kaolinite); B – 'lepidolite' gravel, gardening product.*

Among Li minerals, 'lepidolite' is most abundant and occurs both in the pegmatites and aplites. In pegmatites it occurs mainly as medium to coarse-grained (> 500 µm). In aplites it frequently forms aggregates and is fine-grained (60 µm – 250 µm) to very fine-grained (≤ 60 µm), corresponding to the grain size of the aplite. Other Li-bearing minerals include Li-muscovite, amblygonite - montebrasite, petalite and late secondary phosphates. 'Zinnwaldite' forms as a result of alteration of biotite in the host granite. Cassiterite (< 110 µm), columbite-Mn and tantalite-Mn (20 to 80 µm) also occur in the pegmatites-aplites but are very scarce. The 'lepidolite' is currently processed by optical sorting at the MOTA facilities and sold as decorative material (Fig. 3B).

To expand its business, the company considers the extraction and processing of the 'lepidolite'-bearing pegmatites for lithium production. FAME mineralogical work aims to improve the sorting and to aid further physical and chemical processing to extract Li as an economic by-product. This will result in improved valorisation of the resource at Goncalo and aggregate industry as a whole. The business case shows high applicability for the aggregate industry aiming not only at an improvement of the valorisation of the resource but also at higher flexibility in the marketing of the final product.

Results

QEMSCAN©

'Lepidolite' is the main Li-bearing mineral across all samples. Amblygonite - montebrasite is another major Li-bearing mineral, present in all pegmatite samples as a minor mineral (i.e. generally <2 vol%). Brittle micas and spodumene are present in minor abundances (<1 vol%) but due to similar chemistry are classified as Al silicates by QEMSCAN® analysis (Figs. 4 and 5; University of Exeter).
Muscovite may also contain minor Li. Tin is dominantly hosted by cassiterite which is a rare trace mineral in the aplite and pegmatite samples examined. Columbite group minerals are the major hosts of Nb and Ta. There is limited abundance of rutile (<0.06 vol%), which may also contain Nb.

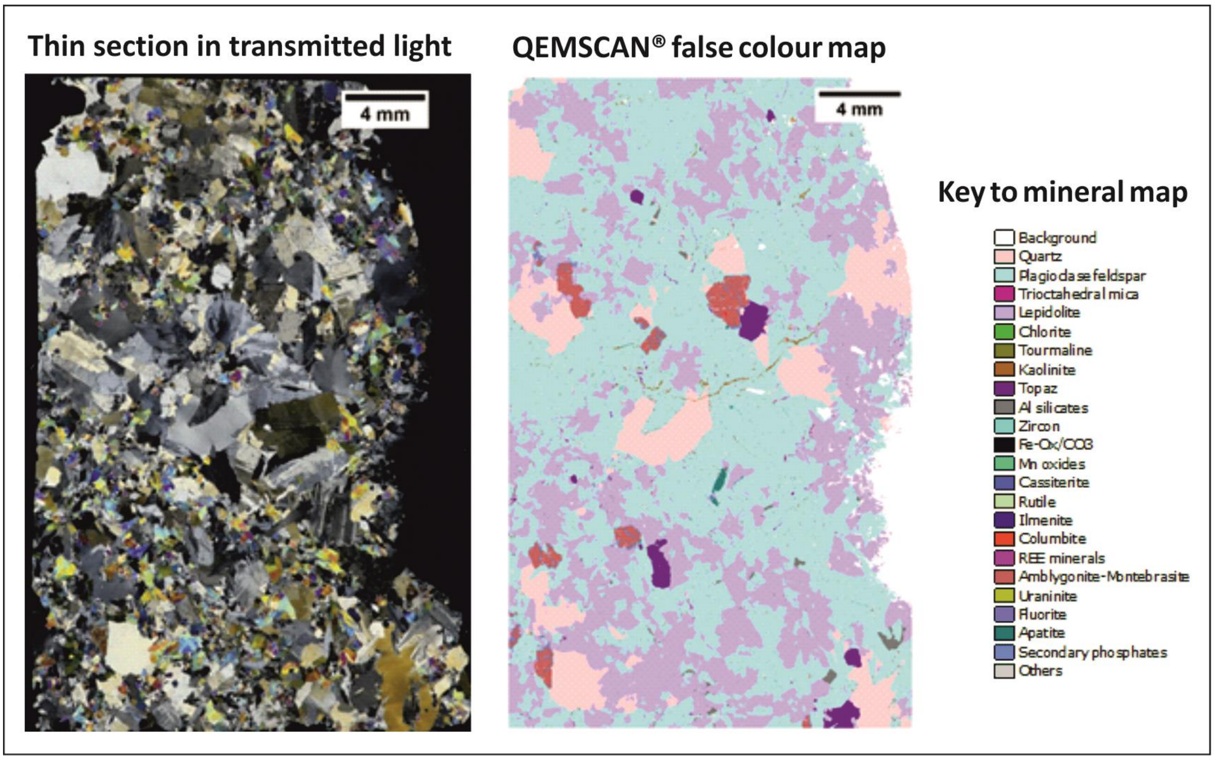

Figure 4. *Image of thin section of pegmatite in transmitted light and its QUEMSCAN© map.*

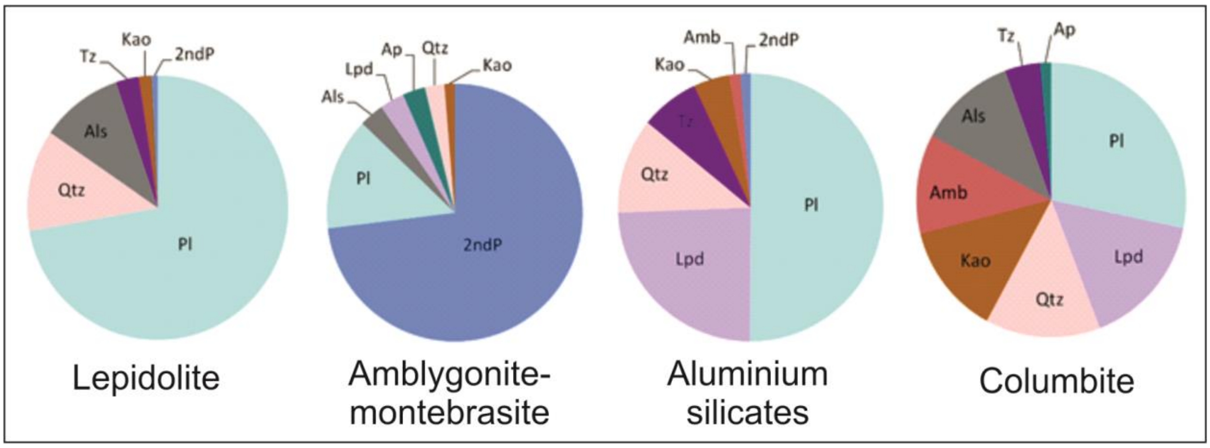

Figure 5.*Visual representation of mineral associations.*

Electron-microprobe analysis

QEMSCAN® data were verified by e-probe data (Figs. 6 and 7; Cameca SX100, NHM London).

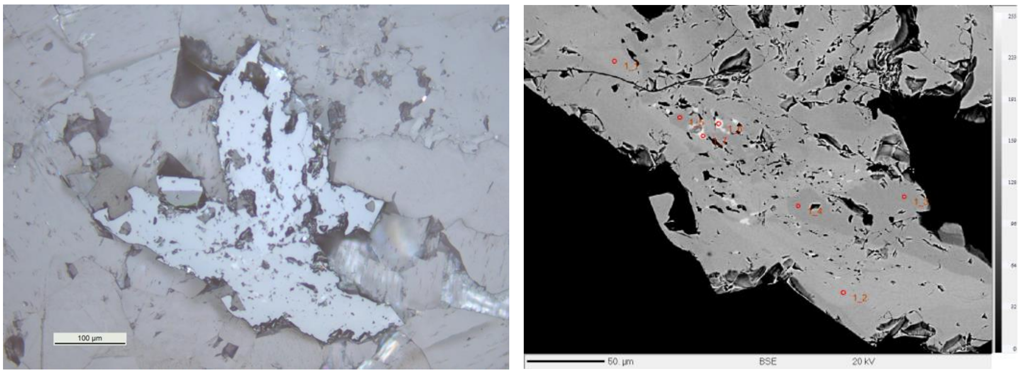

Figure 6. *Reflected light image of a Ta-rich cassiterite grain and EPMA results of minor phases. Lighter areas correspond to cassiterite with Ta (up to 9 wt.%) and Nb (up to 1.5 wt.%). Darker patches correspond to pure cassiterite composition.*

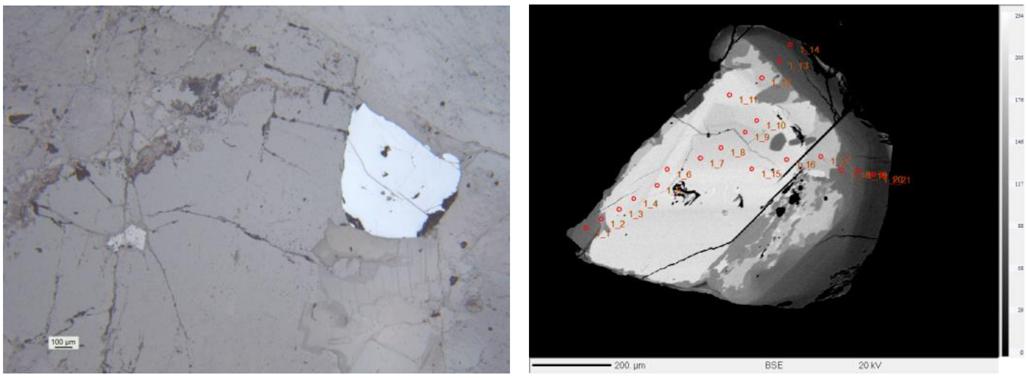

Figure 7. *Reflected light image and EPMA results of a zoned columbite-Mn/tantalite-Mn grain (columbite – darker area at the rim with 0.5 wt.% Sn and up to 33 wt.% Nb; tantalite – brightest area with up to 59 wt.% Ta).*

Conclusions

Rare-element granitic pegmatites are well recognised for the diversity and concentrations of metal ores that they host, including “critical elements” (as defined as by EU) such as Ta and Nb (Linnen et al., 2012). Although lithium is by far the main commodity of the Gonçalo pegmatites (where currently as final product ‘lepidolite’ gravel is produced as decorative stone), utilising a complex mineral processing could result also in the recovery of by-product elements from this and similar other pegmatite deposits.

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